**Citation:**

McCaffrey TA, Rennie KL, Kerr MA, Wallace JM, Hannon-Fletcher MP, Coward WA, Jebb SA, Livingstone MB. Energy density of the diet and change in body fatness from childhood to adolescence; is there a relation? *Am J Clin Nutr*. 2008 May; 87 (5): 1,230-1,237.

**PubMed ID:** 18469244

**Study Design:**

Prospective Cohort Study

**Class:**

B - Click here for explanation of classification scheme.

**Research Design and Implementation Rating:**

POSITIVE: See Research Design and Implementation Criteria Checklist below.

**Research Purpose:**

- To calculate energy density (ED) with the use of five different, published methods and to assess the relationship between ED of the diet in childhood and change in fat mass from childhood to adolescence
- To evaluate whether the relationship between ED and change in fat mass were independently associated with the ED of snacks compared with meals.

**Inclusion Criteria:**

- Participant in original baseline study
  - Student in primary school in the Coleraine area of Northern Ireland between 1996 and 1998
  - Age six to eight years
  - Living with biological parents
- Parents and student agreed to participate in follow-up study
- Had complete food diary from baseline study.

**Exclusion Criteria:**

Students with insufficient food diaries were excluded from the dietary intake analysis (N=2).

**Description of Study Protocol:**

**Recruitment**

- Baseline study (N=115)
- Parents of eligible children contacted via letter through primary schools
- If interested, they were interviewed in their homes

- 44% (N=50) of original participants agreed to participate in follow-up study.

**Design**

Prospective cohort study.

**Dietary Intake/Dietary Assessment Methodology**

- At baseline, dietary intake was assessed by a seven-day weighed dietary record. This was assessed concurrently with doubly labeled water (DLW) measurements of total energy expenditure (TEE)
    - Parents were issued digital weighing scales and instructed how to weigh and record all food and drinks consumed, as well as leftovers, for seven days. Parents were also trained to use the scales and researchers observed their technique
- Parents recorded the time of consumption and whether it was a meal or snack (based on their perception)
- Families were visited at home twice to ensure protocol was being adhered to and to monitor compliance
- Researchers checked for obvious omissions by probing the parents
- Food eaten outside the home was identified by brand name and packet size or by empty wrappers. At each home, the researcher checked these and added missing details as needed
- Food diaries were excluded from analysis if insufficient information was recorded.

**Blinding Used**

Not applicable.

**Intervention**

Not applicable.

**Statistical Analysis**

- Data were assessed for normality with the use of the Shapiro Wilks test
- Differences between sexes were assessed with T-tests and the non-parametric Mann-Whitney U test, as appropriate
- The variance between Energy Density (ED) methods was calculated as the intraindividual (within-person) variance and the inter-individual (between-person) variance
- Correlations between ED methods was assessed with the use of Spearman's correlation coefficient (r)
- When the distribution of $FMI_{dif}$ was examined, it was found that girls had gained more between baseline and follow-up. To adjust for the skewed data, data were categorized based on sex-specific tertiles
- Participants in the first and second tertiles of $FMI_{dif}$ had significantly lower change in FMI than did participants in the tertile of $FMI_{dif.}$ The data were subsequently compared as the lowest tertiles (first and second) compared with the third
- Logistic regression was used to examine associations between the change in FNI and ED of the diet at baseline, with the first and second tertiles compared third tertile of $FMI_{dif}$ as the dependent variable and the ED methods as separate independent variables, with adjustment for sex, pubertal status and misreporting (EI: EE) in the most parsimonious model
- Other variables that did not contribute to the model included age at baseline, time between measurements (in months) and tertile of baseline FMI
- The most parsimonious models examined were:

- Model 1: Sex plus pubertal status plus ED method
- Model 2: Sex plus pubertal status plus EI:EE plus ED method
- Data were analyzed with the use of multiple regression
- Values of $P<0.05$ were regarded as statistically significant
- All statistical analyses were performed with SPSS.

**Data Collection Summary:**

**Timing of Measurements**

- Following protocol from the baseline study, measurements took place during the school term and were conducted during a one-year period
- 48 children (30 boys, 18 girls) were initially studied at age six to eight years
- At baseline and follow-up, TEE was measured over a 10-day period using the DLW method
- Fat free mass (FFM) was also calculated from total body water by dividing the water content of fat-free tissue with age- and sex-specific values
- Fat mass (FM) was calculated as the difference between body weight and FFM
- FM was expressed as a Fat Mass Index (FMI). The difference between FMI at baseline and follow-up was calculated as follow-up FMI - baseline FMI=$FMI_{dif}$.

**Dependent Variables**

- BMI ($kg/m^2$)
- Overweight status
- Waist circumference (cm)
- Total energy expenditure (kJ per day)
- Fat mass (kg)
- Fat mass index (FMI) ($kg/m^2$)
- Fat-free mass (FFM) (kg)
- Fat free mass index (FFMI) ($kg/m^2$).

**Independent Variables**

- Dietary intake: Measured via seven-day weighted dietary record, assessed concurrently with doubly labeled water measurements of total energy expenditure
- Energy Density (ED)
  - ED(all): All foods and all energy-containing beverages and energy-free beverages, including water
  - ED (food): All foods; milk consumed with breakfast cereal counted as food; excluded soups, beverages, milk consumed as a drink
  - ED (soup): All foods, milk as food and soups; excludes beverages
  - ED (solid): All solid foods; excludes milk as food, soups, beverages
  - ED (energy): All foods, milk as food, soups and energy-containing beverages (>21kJ per 100g); excludes energy-free and very-low-energy beverages (e.g., diet drinks, coffee, tea).

**Control Variables**

- Sex
- Pubertal status
- Energy intake: Energy expenditure (misreporting).

**Description of Actual Data Sample:**

- *Initial N:* N=115
- *Attrition (final N):*
  - 50 participants (44%) participated in follow-up study
  - Two food diaries were excluded from the dietary analysis due to incomplete information
  - N=48 (30 boys, 18 girls)
- *Age:*
  - Baseline: Six to eight years
  - Follow-up: 13-17 years
- *Ethnicity:* No information provided
- *Other relevant demographics:* No information provided
- *Anthropometrics:*
  - No significant differences were observed between participants who declined to take part in the follow-up and those who participated at both baseline and follow-up, in terms of age, weight, height, BMI, WC, TEE, EI:EE, parental BMI and energy and macronutrient intakes
  - At baseline, boys had significantly higher TEE (P=0.004), FFM (P=0.020) and FFM index (P=0.007) than did girls
  - Girls had higher FM (P=0.035), FMI (P=0.010) and percentage of body fat (P=0.001) than did boys
  - 13% of boys (3% obese) and 28% of girls (6% obese) were classified as overweight and obese, although the proportion of boys and girls overweight or obese was not significant (P=0.227)
- *Location:* Coleraine area of Northern Ireland.

**Summary of Results:**

**Table 2. Logistic Regression Analyses of Lowest Gain Compared with Highest Gain in Fat Mass Index (FMI; in kg/m$^2$) Between Childhood (Six and Eight Years) and Adolescence (13-16 Years) According to Energy Density Models[1]**

| | Odds Ratio (95% CI) | P |
|---|---|---|
| **Model 1[2]** | | |
| ED (all) | 1.237 (0.529, 2.892) | 0.623 |
| ED (food) | 2.105 (1.081, 4.100) | 0.029 |
| ED (soup) | 2.132 (1.098, 4.141) | 0.025 |
| ED (solid) | 1.922 (1.049, 3.525) | 0.035 |
| ED (energy) | 1.576 (0.65, 3.823) | 0.314 |
| **Model 2[3]** | | |
| ED (all) | 1.234 (0.526, 2.898) | 0.629 |
| ED (food) | 2.124 (1.081, 4.172) | 0.029 |
| ED (soup) | 2.161 (1.099, 4.251) | 0.026 |

| | | |
|---|---|---|
| ED (solid) | 1.94 (1.054, 3.571) | 0.033 |
| ED (energy) | 1.596 (0.653, 3.904) | 0.306 |

[1]Lowest gain (sex-specific tertiles 1 and 2) compared with highest gain (tertile 3). $ED_{all}$, energy density (ED) of all food and beverages; $ED_{food}$, ED of solid foods and milk as a food (e.g., consumed with breakfast cereal); $ED_{soup}$, ED of solid foods, milk as a food and soup; $ED_{solid}$, ED of solid foods only; $ED_{energy}$, ED of foods and beverages in which energy was >21kJ per 100g.
[2]Includes sex plus pubertal status plus ED method
[3]Includes sex plus pubertal status plus ratio of energy intake (in kJ per day) to energy expenditure (in kJ per day by doubly labeled water) plus ED method

**Other Findings**

- No significant differences were observed between girls and boys in the overall ED of their diet
- The correlation coefficients between ED methods were highly significant
- The ED of snacks was significantly higher than was that of meals when ED was calculated by ED (food), ED (soup) and ED (solid) methods (P,0.001 in each case)
- At the group level, the ED (all) and ED (energy) of the total diet at baseline were not significantly related to change in body fatness (FMI) between baseline and follow-up
- ED (food), ED (soup) and ED (solid) of the total diet at baseline increased the odds of being in the highest category of $FMI_{dif}$.

**Author Conclusion:**

- ED (all) or ED (energy) were not associated with change in FMI, but when ED was calculated excluding beverages as ED (food), ED (soup) or ED (solid), participants who had the most energy dense diet in childhood had the highest gain in FMI into adolescence
- Associations observed between variables depend on the method used to calculate ED
- ED of self-defined meals or snacks by any method of calculating ED did not predict change in body fatness
- Self-defined snacks had higher ED than did meals.

***Reviewer Comments:***

*The authors note the following:*

***Strengths***

*Low amounts of EI misreported at baseline as assessed with estimates of TEE by DLW.*

***Limitations***

- *Small sample size at baseline and follow-up*
- *Accuracy of self-assessed puberty status*
- *Interpretation of results differs considerably depending on the methods used to calculate ED and the accuracy of the measure of body composition or obesity status.*

*Research Design and Implementation Criteria Checklist: Primary Research*

| Relevance Questions | | |
|---|---|---|
| 1. | Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies) | Yes |
| 2. | Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about? | Yes |
| 3. | Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice? | Yes |
| 4. | Is the intervention or procedure feasible? (NA for some epidemiological studies) | Yes |

| Validity Questions | | |
|---|---|---|
| **1.** | **Was the research question clearly stated?** | Yes |
| 1.1. | Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified? | Yes |
| 1.2. | Was (were) the outcome(s) [dependent variable(s)] clearly indicated? | Yes |
| 1.3. | Were the target population and setting specified? | Yes |
| **2.** | **Was the selection of study subjects/patients free from bias?** | Yes |
| 2.1. | Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study? | Yes |
| 2.2. | Were criteria applied equally to all study groups? | Yes |
| 2.3. | Were health, demographics, and other characteristics of subjects described? | Yes |
| 2.4. | Were the subjects/patients a representative sample of the relevant population? | ??? |
| **3.** | **Were study groups comparable?** | Yes |
| 3.1. | Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT) | N/A |
| 3.2. | Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline? | Yes |
| 3.3. | Were concurrent controls used? (Concurrent preferred over historical controls.) | N/A |

| | | |
|---|---|---|
| 3.4. | If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis? | Yes |
| 3.5. | If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.) | N/A |
| 3.6. | If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")? | N/A |
| **4.** | **Was method of handling withdrawals described?** | Yes |
| 4.1. | Were follow-up methods described and the same for all groups? | Yes |
| 4.2. | Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.) | Yes |
| 4.3. | Were all enrolled subjects/patients (in the original sample) accounted for? | Yes |
| 4.4. | Were reasons for withdrawals similar across groups? | ??? |
| 4.5. | If diagnostic test, was decision to perform reference test not dependent on results of test under study? | N/A |
| **5.** | **Was blinding used to prevent introduction of bias?** | Yes |
| 5.1. | In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate? | N/A |
| 5.2. | Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.) | Yes |
| 5.3. | In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded? | Yes |
| 5.4. | In case control study, was case definition explicit and case ascertainment not influenced by exposure status? | N/A |
| 5.5. | In diagnostic study, were test results blinded to patient history and other test results? | N/A |
| **6.** | **Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?** | Yes |
| 6.1. | In RCT or other intervention trial, were protocols described for all regimens studied? | N/A |
| 6.2. | In observational study, were interventions, study settings, and clinicians/provider described? | N/A |

| | | |
|---|---|---|
| 6.3. | Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect? | Yes |
| 6.4. | Was the amount of exposure and, if relevant, subject/patient compliance measured? | Yes |
| 6.5. | Were co-interventions (e.g., ancillary treatments, other therapies) described? | N/A |
| 6.6. | Were extra or unplanned treatments described? | N/A |
| 6.7. | Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups? | Yes |
| 6.8. | In diagnostic study, were details of test administration and replication sufficient? | N/A |
| **7.** | **Were outcomes clearly defined and the measurements valid and reliable?** | Yes |
| 7.1. | Were primary and secondary endpoints described and relevant to the question? | Yes |
| 7.2. | Were nutrition measures appropriate to question and outcomes of concern? | Yes |
| 7.3. | Was the period of follow-up long enough for important outcome(s) to occur? | Yes |
| 7.4. | Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures? | Yes |
| 7.5. | Was the measurement of effect at an appropriate level of precision? | Yes |
| 7.6. | Were other factors accounted for (measured) that could affect outcomes? | Yes |
| 7.7. | Were the measurements conducted consistently across groups? | Yes |
| **8.** | **Was the statistical analysis appropriate for the study design and type of outcome indicators?** | Yes |
| 8.1. | Were statistical analyses adequately described and the results reported appropriately? | Yes |
| 8.2. | Were correct statistical tests used and assumptions of test not violated? | Yes |
| 8.3. | Were statistics reported with levels of significance and/or confidence intervals? | Yes |
| 8.4. | Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)? | Yes |
| 8.5. | Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)? | Yes |
| 8.6. | Was clinical significance as well as statistical significance reported? | Yes |

| | | |
|---|---|---|
| 8.7. | If negative findings, was a power calculation reported to address type 2 error? | ??? |
| **9.** | **Are conclusions supported by results with biases and limitations taken into consideration?** | Yes |
| 9.1. | Is there a discussion of findings? | Yes |
| 9.2. | Are biases and study limitations identified and discussed? | Yes |
| **10.** | **Is bias due to study's funding or sponsorship unlikely?** | Yes |
| 10.1. | Were sources of funding and investigators' affiliations described? | Yes |
| 10.2. | Was the study free from apparent conflict of interest? | Yes |